

BEFORE THE
Federal Communications Commission
WASHINGTON, D.C. 20554

In the Matter of)	
)	
An Inquiry Into the Commission's Policies and)	MM Docket No. 93-177
Rules Regarding AM Radio Service Directional)	
Antenna Performance Verification)	

**REPLY COMMENTS OF THE
AM DIRECTIONAL ANTENNA PERFORMANCE VERIFICATION COALITION**

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Executive Summary

The AM Directional Antenna Performance Verification Coalition (“Coalition”) hereby replies to the comments filed in response to the Media Bureau’s May 23, 2007 Public Notice soliciting input on the Coalition’s May 4, 2007 recommendations that the FCC authorize the use of moment method computer modeling to demonstrate that an AM directional antenna (“DA”) performs as authorized.

The Coalition respectfully disagrees with the comments filed that field strength measurements are required to accurately determine the shapes of AM directional antenna (“DA”) patterns. In fact, the Coalition believes that using the proposed techniques of moment method modeling, sample system construction and sampling system testing, it generally will be possible to adjust DA patterns to their required shapes more accurately than with antenna proofs under the present rules.

In response to the specific suggestions and concerns raised concerning the rules proposed by the Coalition, the following information is provided:

- ▶ The Coalition has proposed a limited use of moment method modeling, in that it is intended to relate observable tower parameters to their corresponding far-field relationships through numerical integration of their vertical currents. No far field calculations are involved.
- ▶ The proposed rules address the modeling of the physical details of towers with the requirement for a maximum vertical segment length (10 electrical degrees) for tower models and that the calculations be made for reference points no higher than one electrical degree above ground level.

- ▶ The relationship between radiator current distribution and far field values can be most easily calibrated by impedance measurements of the simple open circuit and short circuit conditions used as a basis for calibrating the moment method model.
- ▶ Using single wire models with length adjustments within a specified small range allows a wide variety of software to be used to obtain accurate array element field parameters by numerical integration.
- ▶ The complexity of circulating currents on shunt fed towers makes simple, straight forward modeling difficult. Therefore, they have not been considered for use in the proposed rules.
- ▶ As the Coalition has proposed, moment method modeling should relate the field ratios of AM DA elements to their calculated current moment ratios.
- ▶ Examples of unsuccessful moment method modeling and discrepancies with antenna monitor parameters are irrelevant since there is no known relationship between monitoring locations and far field conditions, and there is no calibration of the accuracy of the sample systems used for the cases shown.
- ▶ Appropriate sample loop height is determined by the calculation of the percentage of total element height where zero current is present in the non-radiation, detuned situation.
- ▶ A revision to the proposed Section 73.151(a)(2)(i) is provided to eliminate a conflict in the proposed requirements for placing devices to sample the base voltages of towers.
- ▶ The Coalition proposes that reference field strength measurement locations be required to provide a simple method to determine evidence of possible radiation pattern changes.

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To: The Commission

REPLY COMMENTS

The AM Directional Antenna Performance Verification Coalition ("Coalition") hereby replies to the remaining comments filed in response to the Media Bureau's May 23, 2007 Public Notice in the above-captioned proceeding. *See* Public Notice, "Comment Sought on Proposed Rules Permitting Antenna Modeling To Verify AM Directional Antenna Performance," (DA 07-2143, released May 23, 2007). In that Public Notice, the Media Bureau solicited comments on the Coalition's May 4, 2007 recommendations that the FCC authorize the use of moment method computer modeling to demonstrate that an AM directional antenna ("DA") performs as authorized.

In its first submission of reply comments in this proceeding, which were filed with the Commission on September 5, 2007, the Coalition addressed issues raised in connection with the Coalition's proposed new rule under Part 17 that would harmonize the disparate treatment afforded under Section 22.371, Section 27.63, and Section 73.1692 with respect to disturbances caused to AM stations as a consequence of construction near or installation on an AM broadcast antenna system or tower. In this submission, the Coalition addresses the remaining comments submitted concerning its

recommendation that the FCC authorize the use of moment method computer modeling to demonstrate that AM directional antennas perform as authorized.¹

I. The Efficacy of Measured Field Strengths for DA Proofing

Some of the comments filed assumed that radial field strength measurements are required to accurately determine the shapes of AM DA patterns. Comments of R. Morgan Burrow, Jr. (“Burrow”) at 1-2; Comments of Greater Media, Inc. and Charles A. Hecht & Associates, Inc. (“Greater Media”) at 3-5; Comments of Henry Communications (“Henry”) at 1-2; Comments of Donald L. Markley (“Markley”) at 2; Comments of William J. Sitzman, President, Independent Broadcasting Consultants, Inc. (“Sitzman”) at 1. The Coalition respectfully disagrees. Indeed, for the reasons that follow, the Coalition expects that moment method proofs will in many cases yield results that are superior to traditional field strength measurement proofs in terms of interference protection between stations.

Field strength measurements are made with instruments that actually measure magnetic field although their meters indicate mV/M through a conversion process that assumes that a propagating plane wave is being measured. It is the propagating wave from the array that is supposed to be proven by radial measurements, but the measurements generally are made at ground level with numerous nearby conductors that have their own magnetic fields that disturb the magnetic field component of the propagating wave, including underground conductors. In urban areas, it is typical to find pronounced scatter of directional field strength measurements due to the presence of objects that reflect and locally disturb the magnetic field component of the propagating

¹ The members of the Coalition are identified on Attachment A.

wave that is measured by a field strength meter. On deep null radials, the scatter can be extreme.

The errors introduced from local magnetic field disturbances are not randomly distributed about a mean value representing the actual radiation along a null radial, since the theoretical field is very low and any disturbances tend to increase, not decrease, the field strength meter's indication. The Coalition notes that the fields produced by a directional antenna are two-dimensional vector quantities (*i.e.*, they have both magnitude and phase), and that, in the case of a null radial, the sum of the vector fields from the towers of the array is a two-dimensional resultant lying very close to the origin of the complex plane. Disturbances to such a vector appear as errors in both magnitude and phase. Because a field strength meter yields only single-dimensional information on the magnitude of the resultant, its indications cannot be statistically analyzed to cancel random errors as can be done when true single-dimensional quantities are measured.

A simplified example illustrates this point. Consider a gun range problem where, for ease of math, it is posited that shifting winds cause errors in equal number that alternately make bullets miss by 20 cm to the left and right of the point-of-aim on a distant target. If 10 shots are fired, 5 will hit 20 cm to the right (20 cm at 0 degrees on the complex plane) and 5 will hit 20 cm to the left (20 cm at 180 degrees on the complex plane) of the point-of-aim. It is desired to confirm that the gun is aimed at the center of the bull's-eye (the bullets would go there if the wind were not blowing). If the point of aim is actually at the center of the bull's-eye and the target is analyzed viewing the 20 cm misses as single-dimensional quantities (like field strength measurements), it will be concluded that the average error is 20 cm and that the gun is not correctly aimed. If the

errors had been averaged as complex numbers, though, it would have been concluded that the aim was correct, since the average of 5×20 (for the hits that are 20 cm at 0 degrees from the center on the complex plane) and 5×-20 (for the hits that are at 20 cm at 180 degrees from center on the complex plane) is 0. If the gun is re-aimed to try to find the center of the bull's-eye by looking at the average single-dimensional error, it will never be possible to reduce it to anywhere near zero since re-aiming left or right a few centimeters will result in half of the errors going up and half going down. With the point of aim 20 cm to the right or left of the center of the bull's-eye, for instance, the average error of the five shots at the center and five shots displaced by 40 cm will still be 20 cm using single-dimensional analysis.

The method of statistical analysis implicit in radial ratio averaging of AM DA field strength measurements assumes what is known as a normal distribution. It assumes that the truth lies in the middle of something approximating a bell curve representing field strength measurement data plotted as single-dimensional quantities. It is obviously a flawed method for analyzing field strength data along a null radial for which the AM DA radiation has been reduced to zero, as the bell curve – or whatever curve is defined by the data – only represents errors instead of the actual radial field. Radial field strength measurements that provide information on the average of measurement errors instead of the actual radiated field introduces a layer of error into the process of proving that the array element parameters of an AM DA are adjusted properly. Attempts to manipulate the errors by adjustment of a DA pattern's parameters can lead to misadjustment of the pattern insofar as its properties for protecting other stations from interference are concerned. It is obvious that the use of scalar field strength data alone cannot result in

accurate determination of the radiated field strength patterns of AM DAs in the real world environment.

A. Complex Plane Mapping to Analyze Field Strength Scatter

In the case of scattered field strength measurement data along an AM DA proof radial, the errors may be viewed as complex numbers in a “constellation” using the single-dimensional data available from a field strength meter with the application of mathematical techniques that track how individual point field strength measurements change when the directional antenna parameters are changed. When the antenna parameters are adjusted to different values, a difference vector is introduced in each radial direction. These difference vectors, which can be calculated from the parameter changes that are made, can be related to observed field strength changes at measurement points to infer the angles of the indicated unattenuated fields. A plot of the indicated fields at various points on a radial, in a process known as complex plane mapping, can be used for diagnostic purposes and to determine if the desired radial average ratio can be achieved by adjustment of the directional antenna parameters. The plot may be scaled to mV/M at one kilometer unattenuated field and the vector reference angle set to the angle of the field of the reference tower of the array in the radial direction for convenient analysis.

One method of analyzing multiple points along an AM DA null radial having scattered field strengths is the talk down method, which solves for observed resultants at individual radial points using the antenna monitor parameter changes that are found necessary to reduce their field strengths to zero. This is accomplished by experimentally adjusting phasor controls while receiving field strength information from a field strength

meter at each location being studied, oriented toward the station, until the observed field strength becomes, for all practical purposes, zero. The antenna monitor parameters are then used to calculate the difference vector relative to an assumed set of antenna monitor parameters. The difference vector at each point, with 180 degrees added to its angle (relative to the angle of the reference tower's field), is the observed far-field resultant for the reference parameters at that location.

Complex plane mapping techniques, because they allow the field strengths measured at individual radial points to be analyzed in terms of the unattenuated DA radiation that they represent, are useful for investigating the nature of scattered radial measurements such as are commonplace with DA patterns having highly suppressed nulls. When it proves impossible to reduce the radiation indicated by conventional radial average ratio analysis to below the required standard pattern field on a radial, complex plane mapping of individual radial points can be used to determine the nature of the problem and, if possible, plan a field strength measurement program making use of points that are found to be representative of the actual pattern shape.

If the scattered measurements are convergent on a centroid located outside the standard pattern circle (a circle with a radius equal to the standard pattern field for the radial and centered on the origin – indicative of the region where the measured fields must be to indicate that the inverse field is below the standard pattern value) on the complex plane, that can indicate that either the parameters are misadjusted or that there is a reradiation source located near the array that is contributing to the far field resultant. Analyzing different radials and examining the options that are available for changing

them by making parameter adjustments can shed light on the question of whether or not there is a reradiation source near the array.

Scattered measurements that are divergent (scattered at different angles) for points closer to an array and convergent around a centroid at greater distances can indicate a reradiating source that is near the radial, but distant from the station, producing a standing wave with its reflected wave back toward the station and adding to the coherent wave propagating along the radial at farther distances. Scattered measurements that are convergent near an array, and then become divergent beyond a certain distance, can indicate diffraction due to the geometry of intervening terrain or refraction at a boundary of differing ground plane dielectric properties (such as at a water-land boundary or a fault line). Scattered measurements that are divergent along entire radials indicate multiple local field disturbances and/or an interference pattern produced by off-azimuth field disturbances, including diffraction or refraction of energy that is radiated from the array in directions other than that of the radial.

In cases of divergent field strength scatter, the field strength measurements are not indicative of a coherent wave propagating along the radial and, therefore, are not useful for proving the DA pattern shape. Much effort has been wasted attempting to make parameter adjustments to reduce the average radiation indicated by scattered radial field strength measurements on many AM DA systems, and sometimes misadjustment has been the end result. In certain cases, where the nature of the measurement error problem has been identified by the use of complex plane mapping techniques, proofs have been run using radial field strength measurement data over limited distance spans where field strengths have been found to be convergent.

B. Complex Plane Mapping Examples Demonstrate Typical Errors

Figure 1 in Attachment B is a vector plot demonstrating how error vectors may be defined for unattenuated complex fields indicated at individual measurement points by the talk down method. In this case, the error vector defines the distance of an indicated complex field outside the standard pattern field of a radial. For null radials, in general, error vectors calculated relative to the theoretical radial resultants would be larger in magnitude. Error vector magnitudes relative to standard pattern values are presented herein, as they are indicative of the degree of adjustment necessary before a satisfactory field strength measurement proof can be run.

Figure 2 in Attachment B shows a case of a scattered radial where the reference DA parameters were determined using moment method modeling and the techniques that have been proposed by the Coalition. The first four points group well within the standard pattern circle and confirm that the parameters have been adjusted so that the magnitude of the coherent wave leaving the site is below the standard pattern field and that it continues to propagate along the radial as a coherent wave for approximately six kilometers before the field strength measurements become contaminated with divergent errors. It is an example of measurement errors resulting from refraction where a river is traversed by a null measurement radial at a significant distance from the transmitter site.

Figure 3 in Attachment B shows another case of water/land boundary refraction that takes place very close to an array. All of the talk down points shown are beyond the river that caused the scatter. It should be noted that no more than two of the ten points are capable of being moved inside the standard pattern circle at the same time by adjusting the DA parameters. No coherent propagating wave exists beyond the river to

measure for proving the directional antenna pattern. It was necessary to prove that the DA pattern shape was correct using measurements made very close to the transmitter site and analyze them to account for near-field proximity effects.

Figure 4 in Attachment B shows a case of scatter resulting from the urban environment near the Meadowlands outside New York City. The pattern was adjusted to parameters that were determined using moment method modeling in a process similar to that proposed by the Coalition, even though the requirements of the proposed rules with regard to the antenna monitor sampling system cannot be met due to the characteristics of the self-supporting towers. The first three points are convergent near the theoretical pattern resultant (indicated by the head of the tower 3 field vector), but all of the points beyond five kilometers show the effects of divergent scatter. It can be seen that further adjustment to reduce the overall radial average of the points whose field strengths include obvious errors could result in distortion of the actual radiated pattern.

Figure 5 in Attachment B shows a case where scatter due to the terrain traversed by the measurement radial introduced divergent errors that are very large relative to the standard pattern field. It was necessary to run the field strength measurements for the proof at very close distances and analyze them to account for near-field proximity effects to have meaningful data upon which to base the measured DA pattern shape.

C. Field Errors lead to Pattern Misadjustment

While the cited examples use information from proofs where alternate measurement approaches were necessary because traditional radial analysis could not be used to prove the pattern shapes, the types of error shown are very common for field strength measurements made on AM DA patterns. It is obvious from the field strength

scatter that is generally encountered along null radials of traditional proofs that field strength measurement errors may make many, if not all, of the measurement points indicate unattenuated field strengths disproportionate to the magnitude of the coherent wave that is propagating from the array. The magnitude of the coherent wave that propagates from the array is what the proof is supposed to prove.

Parameter adjustments made to attempt to correct for localized field strength errors along radials can result in DA pattern misadjustment, even though the misadjustment might not be apparent with a proof run under the present rules. Figure 6 in Attachment B shows a hypothetical DA pattern that protects another station at night that is located at an azimuth of 8.0 degrees true and at a distance where skywave interference can be caused by radiation within a vertical angle range of 28.0 to 41.4 degrees above the horizontal plane. Figure 7 in Attachment B shows the same pattern with augmentations added, using the procedures outlined in the FCC rules, in its null regions to increase the standard pattern field to enclose excessive measured radial field strengths on the null radials. The other station continues to receive exactly the same degree of nighttime protection from the augmented pattern. Figure 8 in Attachment B shows a misadjusted pattern that would pass a proof for the augmented pattern with radial field strength measurements and which the FCC would license under the present rules – despite the fact that the skywave field toward the protected station would more than double with the misadjusted parameters. The protected station would receive 6.1 dB more interfering signal at night than if the directional antenna parameters had been adjusted to their correct values instead of misadjusted to “chase” field strength measurement errors.

D. Eliminating Field Strength Measurement Errors in Proofing

The Coalition believes that with the prescribed techniques of moment method modeling, sampling system construction and sampling system testing, applied within the proposed limitations on array characteristics, it will be possible to adjust DA patterns to their required shapes with no more error – and, in general, less error - than is possible with antenna proofs run under the present rules.

II. Responses to Specific Comments Concerning the Proposed Use of Moment Method Computer Modeling to Verify the Performance of AM Directional Antennas

A. Limited use of Moment Method Modeling is Proposed

Based on a review of some of the comments submitted in this proceeding, it appears that there is some confusion concerning the extent to which moment method modeling will be employed under the Coalition's proposed rules. Specifically, Burrow and Mullaney Engineering, Inc. ("Mullaney") express concerns that different moment method modeling software will produce different results (which the Coalition acknowledges may occur in connection with predicting far-field radiation patterns taking into account factors such as the physical characteristics of towers and antenna site ground conditions) and discuss the efficacy of different software packages for modeling complicated tower structures and feed arrangements – including shunt feeding with skirt wires. Burrow at 2; Mullaney at 3-4.

The Coalition submits that consideration of these issues is not necessary since the Coalition's proposed rules are simply intended to relate observable tower parameters (base currents, loop currents or base voltages) to their corresponding far-field

relationships through numerical integration of their vertical currents. No far-field pattern calculations are involved, as no changes are proposed in how pattern shapes are determined for coverage and allocation analysis. The relationships between observable parameters and the far-field contributions of the individual towers of an array can be established using a wide range of moment method modeling software if the procedures of the proposed rules are followed.

Traditionally, AM antennas have been analyzed assuming sinusoidal current distribution on their elements. Early studies, dating from the 1920s, revealed that the sinusoidal current distribution assumption was satisfactory for determining the radiating properties of antennas, even though it was understood that it was a convenient fiction to avoid the tremendous mathematical complexity of trying to perform calculations using the current distributions of actual, radiating antennas. It can be shown theoretically that radiation cannot take place from a tower with sinusoidal current distribution and that the current distributions of different towers within an AM DA will, in general, not be identical due to mutual coupling effects. For simplicity, however, sinusoidal current distribution is the foundation upon which the methods of pattern far-field calculation built into the FCC Rules and international regulations are based. The Coalition has not proposed to disturb that foundation. Sinusoidal current distribution and perfectly conducting earth will continue to be assumed for pattern calculations using the present methods of the FCC and applicable international agreements. Moment method modeling does indeed make more precise pattern calculations possible and it may at some future point be desirable to further change the FCC's Rules to specify it for pattern calculations,

but that issue – and the software characteristics that would be important in that context – need not be considered at this time.

The Coalition has proposed the use of moment method modeling to predict the actual current distributions of the individual elements of an array, numerically integrate them, and calculate the tower relative fields using their current moment sums. This is a more direct approach than trial-and-error parameter adjustments to produce a desired measured pattern shape – to the extent that the pattern shape can be known despite the errors that are implicit in making field strength measurements in the real-world environment – in order that a set of antenna monitor parameters may be found for the station license. Approximately three decades of experience using numerical modeling to calculate the base impedances of AM directional antenna elements has demonstrated, to the satisfaction of the consulting engineers and broadcasting companies of the Coalition, that moment method modeling also makes it possible to relate tower voltages and currents to far-field DA pattern parameters. This is not surprising since moment method modeling, by the early 1980s, had demonstrated its vast superiority for determining the base impedances of AM directional antenna system towers over methods assuming sinusoidal current distribution. Base impedances are, after all, defined as the ratios of voltages and currents appearing at tower bases.

Based on many years of experience, Coalition members reached a consensus on what array and sampling system characteristics are necessary to allow the use of moment method modeling to relate observed parameters to the tower far-field components of directional antenna patterns. The limitations and requirements of the proposed rules reflect the consensus that was reached through a process that was intended to err on the

safe side with regard to maintaining the integrity of directional antenna patterns without unnecessarily complicating the moment method modeling process or requiring particular expertise in its application.

B. Modeling Array Element Physical Detail

J.L. Smith, PE (“Smith”) suggested in his comments alternate requirements for modeling the physical details of towers used as AM DA system elements and their feedpoints. Smith at 8-10. The Coalition’s proposed rules address these issues with the requirement for a maximum vertical segment length (10 electrical degrees) for tower models – whether modeling with single wires using MININEC or multiple wires using a version of NEC – and that the calculations be made for reference points no higher than one electrical degree above ground level. The reason for the reference point requirement is to ensure that essentially identical results are obtained whether moment method modeling software that calculates currents at the wire segment ends or at the wire segment center points is used – which would be a very significant source of potential error otherwise. The Coalition’s proposed rules were developed to allow maximum flexibility in software selection, and in the experience of Coalition members using different modeling software, the proposed requirements are sufficient to ensure accurate results when the proposed process of matching measured and modeled base impedance matrix data is followed.

C. Using Observed Single-Tower Impedances to Calibrate Model

Some comments challenged the proposed method of using moment method modeling to proof AM DAs, which specifies that measured impedances at tower drive points, with all other towers open circuited and short circuited, be used to confirm that

the specified tower characteristics are appropriate. Markley at 3; Smith at 4, 6-7. The relationships between tower drive voltages and currents of an array to their DA field parameters do not depend critically on the physical characteristics of the tower model as long as the towers are modeled consistently, and many systems may be proofed with satisfactory accuracy without considering measured impedance matrix data at all. It was the consensus of Coalition members, however, that some check must be in place to avoid errors due to nearby electromagnetic environmental issues, such as stray capacitances at tower bases and non-uniform local terrain. The proposed rules require that the moment method model be proven to predict the base impedances of the towers of an array, driven one at a time, with reasonable limits on the array element assumptions, the shunt capacitances and series inductances that are applied to the impedances predicted by the moment method model at the bare tower bases.

The limitations on the extent to which impedances predicted with an overall model (consisting of the moment method model for the actual tower bases and the network model to represent the series and shunt effects that are present at the measured reference point for each tower) must match measured impedances were based on the ratings of the most popular instrument for making AM antenna impedance measurements at this time – the Delta Electronics OIB-3 impedance bridge. Specifically, the modeled impedance matrix must agree within twice the rated accuracy of the Delta bridge, according to its manufacturer's specifications, of the measured impedances. Coalition members agree, based on their experience, that these requirements will provide for satisfactory AM DA performance if the impedances are moment method modeled within

the proposed constraints of tower height and radius, with base networks meeting the proposed shunt capacitance and inductance limitations.

D. Velocity of Propagation in Modeling

The practice of modeling towers at assumed heights other than their physical heights, for which limits were included in the proposed rules, was challenged in certain comments. See Markley at 2; Mullaney at 4; Smith at 10. While the Coalition agrees that it would be inappropriate to specify towers at other than their physical heights in a detailed model representing the individual tower legs and cross members to precisely calculate far-field radiation characteristics, such modeling has not been proposed for proofing AM DAs. The existing FCC methods do not consider the fact that towers behave as delay lines, because of the small, but finite horizontal currents flowing in their cross members that do not contribute to far field radiation – or, for that matter, that vertical radiation characteristics depend on tower equivalent radius. That situation will remain unchanged and the proposed techniques for proofing AM DAs using moment method modeling to numerically integrate tower currents do not depend on using exact physical dimensions for the towers as would be necessary for calculating far-field patterns.

The members of the Coalition, relying on their aggregate experience of many decades of modeling and adjusting AM DAs, have set limits on the degree to which physical heights may be altered to account for the velocity of propagation characteristics of towers. The expedient of using single “fat” wires to represent towers – with their lengths adjusted to account for velocity of propagation effects and their radii selected to represent their cross-sectional areas – allows for a wide variety of software to be used to

obtain accurate results insofar as relating antenna monitor parameters to array element field parameters through numerical integration of tower current is concerned. On the other hand, towers may be modeled using multiple wires representing their leg and cross member sections. In either case, comparison of the modeled results with the required impedance matrix measurements will confirm that the actual tower propagation velocities have been accounted for properly.

E. Shunt Fed Towers as Array Elements

One example of a limitation on the applicability of moment method modeling proofs, to keep analysis methods to an agreed-upon level of simplicity, is the exclusion of shunt fed towers including those using wire skirts which are sometimes known as “folded unipoles.” This is because it is impossible to measure the current that produces the far-field radiation of such a tower directly without including a circulating current component related to the shunt feeding scheme. Thus, an observed current on a tower cannot be related to its far-field DA pattern contribution through the simple process that has been proposed. The Coalition recognizes that a much more complicated version of moment method modeling than has been proposed might make modeling of such towers as DA elements possible and that, when more experience with moment method modeling proofs has accrued, it may be desirable to seek further rule changes to allow it.

F. Only Series-Fed Towers are Proposed for Moment Method Proofing

Certain comments correctly noted that the proposed revisions to Section 73.151 do not make clear that the proposed rules for moment method proofs applied only to series-fed towers because the simplified modeling approach for relating antenna monitor parameters to element far-field magnitude ratios and phases through numerical

integration cannot account for the additional circulating currents that exist on shunt fed towers. Burrow”) at 1, 4; Mullaney at 3-4, 7-8. Because it was the intention of the Coalition to limit the applicability of the proposed rule to series-fed towers, the proposed Section 73.151(a) has been revised to include the following sentence: “Only arrays consisting of series-fed elements may have their performance verified by computer modeling and sample system verification.” *See* Attachment C.

G. Computer Modeling to Establish DA Pattern Parameters

Smith correctly pointed out in its comments that moment method modeling should relate the field ratios of AM DA elements to their calculated current moment ratios. Smith at 12-13. Indeed, that is the method that has been described in peer-reviewed publications and is how the currently available software for moment method modeling of AM DAs works. For this reason, the following sentence has been added after the first sentence of the proposed Section 73.151(a)(2)(i):

“The moment method modeled parameters shall be established by using the verified moment method model to produce tower current distributions that, when numerically integrated and normalized to the reference tower, are identical to the specified field parameters of the theoretical directional antenna pattern.”

H. Comparison with Existing AM DA Parameters

Certain comments addressed the subject of disagreement between the licensed and modeled parameters of existing AM DA systems. Greater Media at 4-5, and Appendixes A&B; Sitzman at 2. The Coalition submits that it is not possible to make a valid comparison of modeling results with the directional antenna parameters that are on file with the FCC for existing stations since it is unlikely that an existing station’s antenna monitor sampling system was constructed and tested to the standards that have been

proposed for stations that elect to conduct moment method modeling proofs, and there is no basis for a valid comparison unless the moment method model is based on actual measured impedance information at the base reference points as specified in the proposed rules. Moreover, existing systems may have been adjusted to alternative parameters that produce the same pattern – which may be determined through a process known as “parameter inversion” or “moding” – or to different parameters selected to optimize null region coverage.

It should be noted that the Coalition’s proposed rules will not prohibit establishing antenna monitor parameters that optimize null region coverage under Section 73.151(b) if the antenna monitor parameters can be shown, through a proof based on field strength measurements, to satisfy the standard pattern requirements. It will be the station licensee’s option to decide which form of proof best meets their requirements.

I. Sampling Loop Height

Smith also has suggested alternate language relating to the placement of sampling loops at heights where the modeled phases equal the theoretical field phases. Smith at 11-12. In this regard, the Coalition notes that its proposed Section 73.151(a)(2)(i) provides that sampling loops be “located at the elevation where the current in the tower would be at a minimum if the tower were detuned in the horizontal plane, as determined by the moment method model....” Specifically, the height of a current null when a tower is detuned is the height at which both the ratio and phase of the tower current represent the theoretical field parameters of the tower when placed in an array. In order to avoid confusion over using modeled heights having velocity of propagation correction, the following sentence has been added to the proposed Section 73.151(a)(2)(i):

“If the tower height used in the model is other than the physical height of the tower, the sampling loop shall be located at a height that is the same fraction of the total tower height as the minimum in tower current with the tower detuned in the model.”

J. Voltage Sampling Points

In reviewing its proposed revisions to Section 73.151, the Coalition determined that a conflict exists in the requirements for placing devices to sample the base voltages of towers in the proposed Section 73.151(a)(2)(i). To eliminate the conflict, the Coalition has revised the second sentence of that section, a copy of which is attached hereto. The revised language is set forth below:

“The samples used to drive the antenna monitor may be current transformers or voltage sampling devices at the outputs of the antenna matching networks or sampling loops located on the towers.”

K. Reference Field Strength Measurement Locations

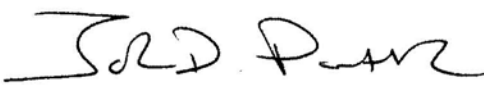
Certain of the comments filed suggested that the requirement to establish monitor points, which will have maximum licensed values, should be maintained as part of the antenna proofing process. *See* Greater Media at 10; Markley at 3; Comments of Potomac Instruments, Inc. (“Potomac Instruments”) at 3-4. The rules proposed by the Coalition provide for the use of external field strength measurements to provide evidence of possible far-field pattern changes by requiring that reference measurement locations be established near the directional antenna pattern maximum and minimum azimuths when a proof using moment method modeling is run. The Coalition submits that its proposed requirement that the reference field strength measurements be maintained in a station’s public file will provide for accountability to FCC inspectors and verifiability by members of the general public and other broadcasters that wish to verify proper DA operation.

III. Conclusion

As the Coalition noted when it initially submitted its recommendations to the Commission, it has been more than six years since the Commission released its initial Notice of Proposed Rulemaking in this proceeding on the use of computer modeling to predict the performance of directional antenna systems. Today, that technology underlying computer modeling is widely accepted and used in the broadcast industry. The Coalition submits that the time has come for the Commission to discontinue its reliance on field strength measurements as the sole method to verify the performance of AM directional antennas. Permitting the use of computer modeling as proposed by the Coalition will result in improved adjustments in AM directional patterns and more stable AM directional antenna arrays.

Respectfully submitted,

**AM DIRECTIONAL ANTENNA
PERFORMANCE VERIFICATION
COALITION**

By: 

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Its Attorneys

ATTACHMENT A

AM DIRECTIONAL ANTENNA PERFORMANCE VERIFICATION COALITION

Broadcasters

Beasley Broadcast Group, Inc.
Bonneville International
Buckley Broadcasting Corporation
CBS Radio Inc.
Citadel Broadcasting Company
Clear Channel Radio
Cox Radio, Inc.
Crawford Broadcasting Company
Cumulus Media Inc.
Emmis Communications Corp.
Entercom Communications Corp.
Entravision Communications Corporation
Family Stations, Inc.
Journal Broadcast Group
Lincoln Financial Media
Morris Communications Company, LLC
Multicultural Radio Broadcasting, Inc.
Peak Broadcasting LLC
Radio One, Inc.
Regent Communications
Saga Communications
Salem Communications Corporation
The Walt Disney Company

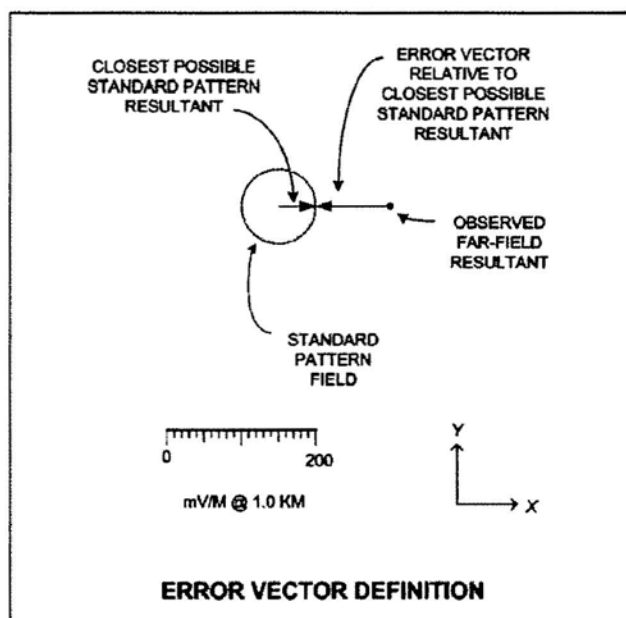
Consulting Engineers/Equipment Manufacturers

Carl T. Jones Corporation
Cavell, Mertz & Associates, Inc.
Communications Technologies, Inc.
du Triel, Lundin & Rackley, Inc.
Edward A. Schober, P.E., Radiotechniques Engineering, LLC, Consulting Engineers
Hammett & Edison, Inc.
Hatfield & Dawson Consulting Engineers, LLC
Khanna & Guill, Inc.
Radiotechniques Manufacturing, LLC
Sellmeyer Engineering

ATTACHMENT B

Referenced Figures

Figure 1

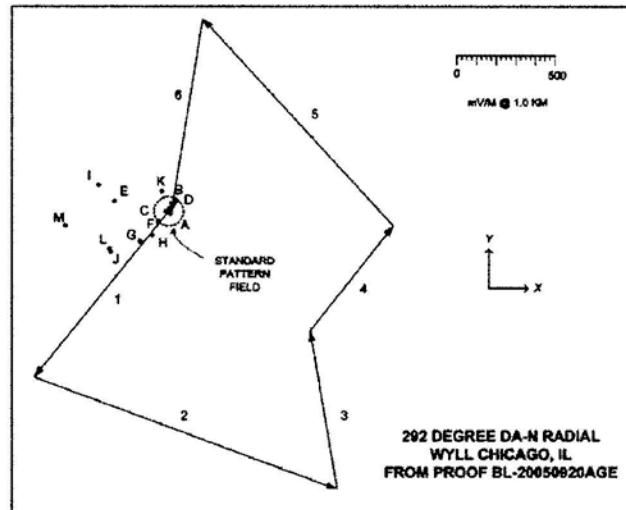


An error vector magnitude, relative to the closest possible vector resultant lying within the standard pattern radiation for the radial azimuth, is calculated for each measurement location that is studied along a radial. The standard pattern radiation value, being a scalar quantity, defines the radius of a circle that is centered at the origin of the vector diagram. For the example shown, the standard pattern field is 50 mV/M and the observed far-field resultant is 150 mV/M. Therefore, the error vector magnitude expressed as a percent of the standard pattern field is:

$$|E| = ((150 - 50) / 50) (100) = 200\%$$

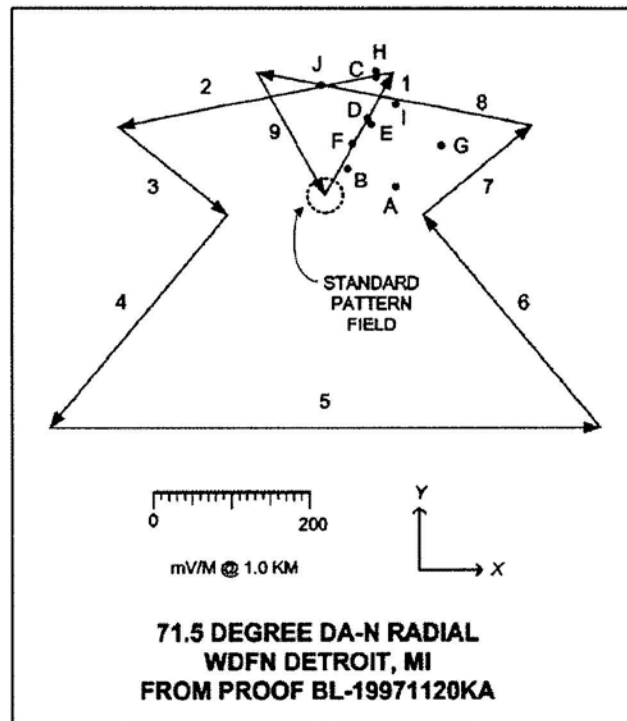
Error vector magnitudes are useful for judging the extent to which measured field strengths at individual points reflect excessive radiation relative to a standard pattern, but whether the excessive radiation results from a coherent wave propagating from the source or localized field disturbances requires consideration of the extent to which the angles of the individual observed far-field resultants diverge.

Figure 2



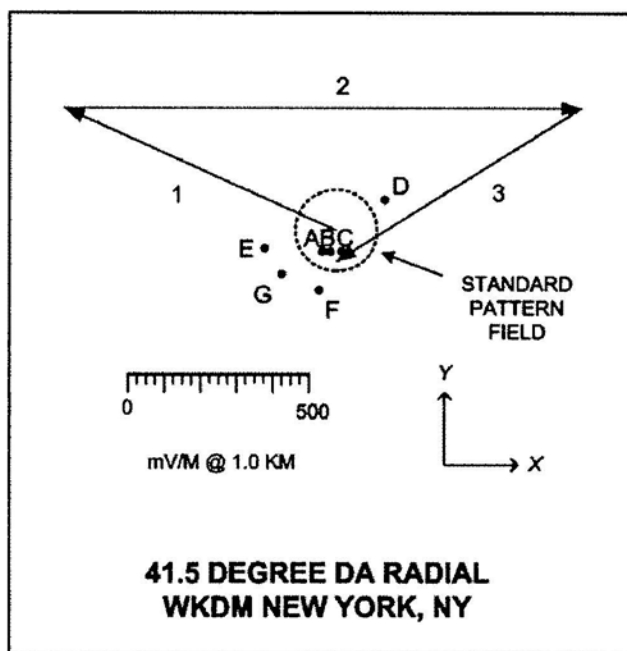
POINT	DISTANCE (KM)	TALK-DOWN ERROR VECTOR MAGNITUDE (%)
A	3.54	--
B	4.36	--
C	5.55	--
D	5.95	--
E	6.71	275
F	8.92	8
G	10.99	183
H	13.86	100
I	15.06	407
J	16.03	374
K	20.04	51
L	24.66	375
M	31.59	617

Figure 3



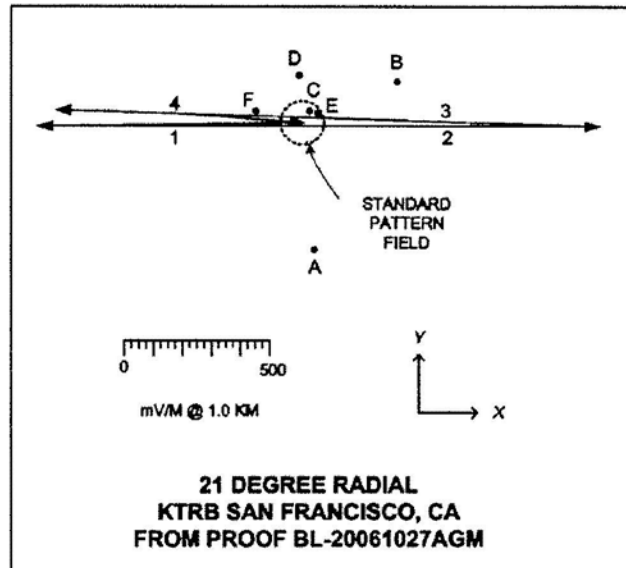
POINT	DISTANCE (KM)	TALK-DOWN ERROR VECTOR MAGNITUDE (%)
A	9.67	331
B	11.40	115
C	12.67	689
D	14.12	436
E	15.47	426
F	20.05	259
G	24.18	675
H	27.94	713
I	28.45	675
J	32.43	570

Figure 4



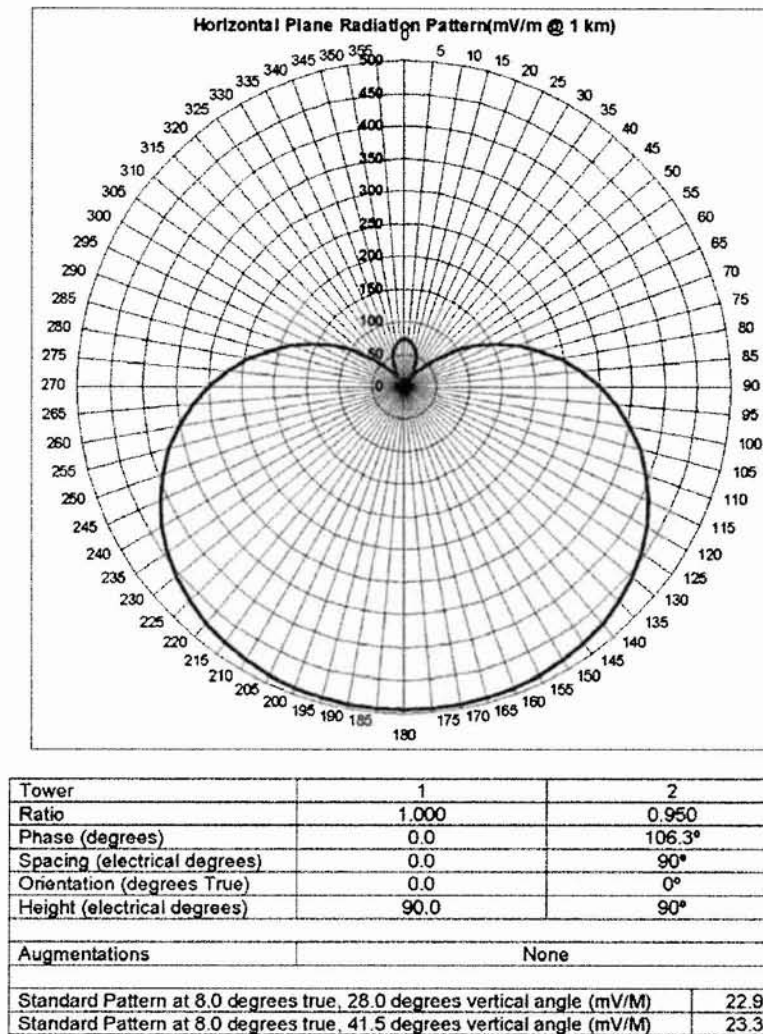
POINT	DISTANCE (KM)	TALK-DOWN ERROR VECTOR MAGNITUDE (%)
A	2.00	--
B	3.22	--
C	3.94	--
D	5.18	37
E	6.33	79
F	7.88	48
G	9.82	64

Figure 5



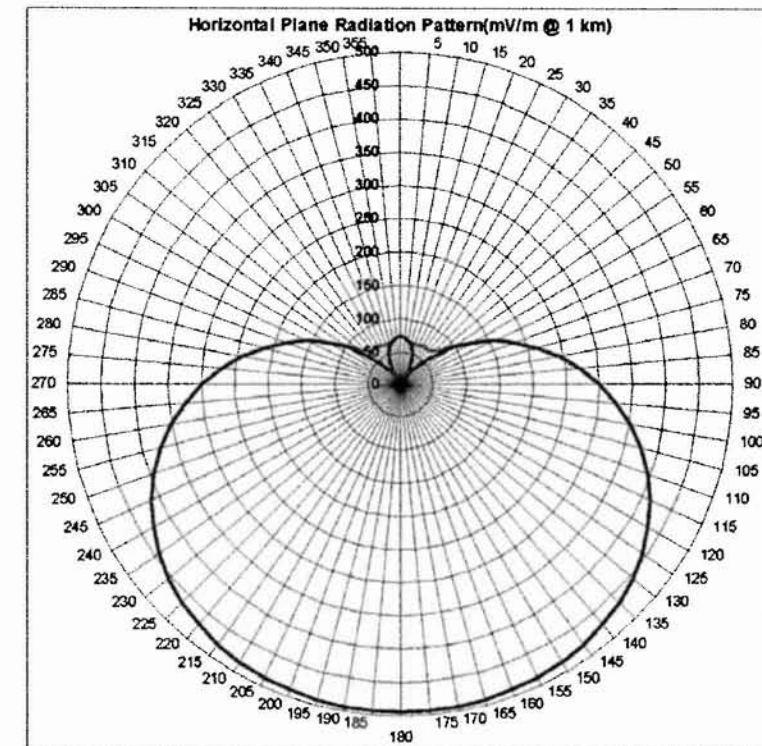
POINT	DISTANCE (KM)	TALK-DOWN ERROR VECTOR MAGNITUDE (%)
A	8.19	460
B	10.60	349
C	11.40	--
D	12.20	112
E	14.80	--
F	15.60	118

Figure 6



CP STANDARD PATTERN (HYPOTHETICAL)

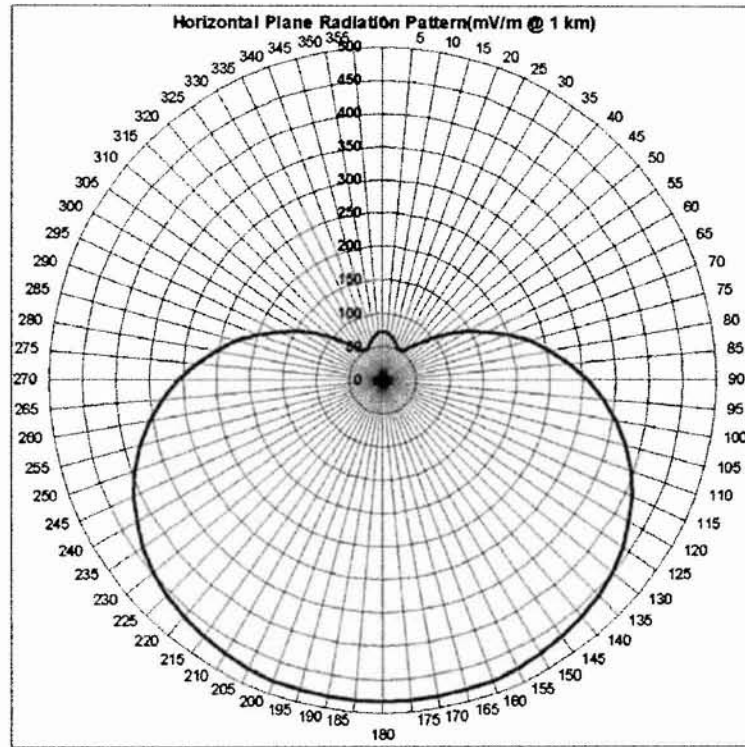
Figure 7



Tower	1	2
Ratio	1.000	0.950
Phase (degrees)	0.0	106.3°
Spacing (electrical degrees)	0.0	90°
Orientation (degrees True)	0.0	0°
Height (electrical degrees)	90.0	90°
Augmentations	66 mV/M, Span = 52°, at 35.0° T and 325.0° T	
Standard Pattern at 8.0 degrees true, 28.0 degrees vertical angle (mV/M)	22.9	
Standard Pattern at 8.0 degrees true, 41.5 degrees vertical angle (mV/M)	23.3	

AUGMENTED CP STANDARD PATTERN (HYPOTHETICAL)

Figure 8



Tower	1	2
Ratio	1.000	0.810
Phase (degrees)	0.0	102.0
Spacing (electrical degrees)	0.0	90°
Orientation (degrees True)	0.0	0°
Height (electrical degrees)	90.0	90°
Augmentations	None	
Standard Pattern at 8.0 degrees true, 28.0 degrees vertical angle (mV/M)		43.6
Standard Pattern at 8.0 degrees true, 41.5 degrees vertical angle (mV/M)		47.4

MISADJUSTED STANDARD PATTERN PROOFED WITHIN
AUGMENTED CP STANDARD PATTERN (HYPOTHETICAL)

ATTACHMENT C

Revisions to Proposed Section 73.151

§73.151 Directional Antenna Performance Verification.

The performance of a directional antenna system may be verified either by computer modeling and sample system verification or by the performance of field strength measurements.

(a) *Computer modeling and sample system verification of modeled parameters to establish operation of directional antennas consistent with the theoretical pattern.* Each element of the directional array shall be modeled by use of a method of moments computer program, using element physical characteristics to establish a system model that does not violate any of the constraints of the computer program used. Only arrays consisting of series-fed elements may have their performance verified by computer modeling and sample system verification.

(1) A matrix of impedance measurements at the base and/or feed point of each element in the array, with all other elements shorted and/or open circuited at their respective measurement locations shall be made. The physical model of the individual antenna elements used in the computer program may be varied to match the measured impedance matrix, but the actual spacings and orientations of the array elements must be used. Towers may be modeled using individual vertical wires to represent them or with multiple wires representing their leg and cross member sections. The resulting model description (consisting of the length, radius and number of segments of each wire for arrays using vertical wire sections to represent the towers, or the length, end-point coordinates and radius of each wire used to represent leg and cross-member sections for arrays using wire tower structure representations) as well as the assumed input feed and base region stray reactances shall be used to generate the drive impedances and sample system parameter values for the operating directional antenna pattern parameters.

(i) For arrays using vertical wires to represent each tower, the radii of cylinders shall be no less than 80% and no more than 150% of the radius of a circle with a circumference equal to the sum of the widths of the tower sides.

(ii) For arrays using multiple wires representing their leg and cross member sections, the individual legs of the tower may be modeled at their actual diameters with appropriate interconnecting segments representing cross members at regular intervals.

(iii) No less than 1 segment for each 10 electrical degrees of the tower's physical height shall be used for each element in the array.

(iv) Base calculations shall be made for a reference point at ground level or within one electrical degree elevation of the actual feed point.

(v) For uniform cross section towers represented by vertical wires, each wire used for a given tower shall be within 75% to 125% of the physical length represented.

(vi) For self-supporting towers, stepped-radius wire sections may be employed to simulate the physical tower's taper, or the tower may be modeled with individual wire sections representing

the legs and cross members.

(vii) The lumped series inductance of the feed system between the output port of each antenna tuning unit and the associated tower shall be no greater than 10 μH unless a measured value from the measurement point to the tower base with its insulator short circuited is used.

(viii) The shunt capacitance used to model base region effects shall be no greater than 250 pF unless the measured or manufacturer's stated capacitance for each device other than the base insulator is used. The total capacitance of such devices shall be limited such that in no case will their total capacitive reactance be less than 5 times the magnitude of the tower base operating impedance without their effects being considered.

(ix) The orientation and distances among the individual antenna towers in the array shall be confirmed by a post-construction certification by a Land Surveyor (or, where permitted by local regulation, Engineer) licensed or Registered in the State or Territory where the antenna system is located.

(2)(i) The computer model, once verified by comparison with the measured base impedance matrix data, shall be used to determine the appropriate antenna monitor parameters. The moment method modeled parameters shall be established by using the verified moment method model to produce tower current distributions that, when numerically integrated and normalized to the reference tower, are identical to the specified field parameters of the theoretical directional antenna pattern. The samples used to drive the antenna monitor may be current transformers or voltage sampling devices at the outputs of the antenna matching networks or sampling loops located on the towers. If sample loops are used, they shall be located at the elevation where the current in the tower would be at a minimum if the tower were detuned in the horizontal plane, as determined by the moment method model parameters used to determine the antenna monitor parameters. Sample loops may be employed only when the towers are identical in cross-sectional structure, including both leg and cross member characteristics; if the towers are of unequal height, the sample loops shall be mounted identically with respect to tower cross members at the appropriate elevations above the base insulator. If the tower height used in the model is other than the physical height of the tower, the sampling loop shall be located at a height that is the same fraction of the total tower height as the minimum in tower current with the tower detuned in the model. Sample lines from the sensing element to the antenna monitor must be equal in both length (within one electrical degree) and characteristic impedance (within two Ohms), as established by impedance measurements, including at the open-circuit resonant frequency closest to carrier frequency to establish length, at frequencies corresponding to odd multiples of $1/8$ wavelength immediately above and below the open circuit resonant frequency closest to carrier frequency, while open circuited, to establish characteristic impedance, and at carrier frequency or, if necessary, at nearby frequencies where the magnitude of the measured impedance is no greater than 200 ohms with the sampling devices connected. Samples may be obtained from current transformers at the output of the antenna coupling and matching equipment for base-fed towers whose actual electrical height is 120 degrees or less, or greater than 190 electrical degrees. Samples may be obtained from base voltage sampling devices at the output of the antenna coupling and matching equipment for base-fed towers whose actual electrical height is greater

than 105 degrees. Samples obtained from sample loops located as described above can be used for any height of tower. For towers using base current or base voltage sampling derived at the output of the antenna coupling and matching equipment, the sampling devices shall be disconnected and calibrated by measuring their outputs with a common reference signal (a current through them or a voltage across them, as appropriate) and the calibration must agree within the manufacturer's specifications.

(ii) Proper adjustment of an antenna pattern shall be determined by correlation between the measured antenna monitor sample indications and the parameters calculated by the method of moments program, and by correlation between the measured matrix impedances for each tower and those calculated by the method of moments program. The antenna monitor sample indications must be initially adjusted to agree with the moment method model within ± 5 percent ratio and ± 3 degrees phase. The measured matrix impedances must agree with the moment method model within ± 2 ohms and $\pm 4\%$ resistance and reactance.

(3) Reference field strength measurement locations shall be established in directions where the standard pattern unattenuated field strength is within 3 dB of the value for each pattern minimum and the absolute pattern maximum. The field strength shall be measured at each reference location at the time of the proof of performance and its value, along with a complete description of the location, shall be placed in the station's public inspection file.

(b) *Field strength measurements to establish performance of directional antennas.*

(1) In addition to the information required by the license application form, the following showing must be submitted to establish, for each mode of directional operation, that the effective measured field strength (RMS) at 1 kilometer (km) is not less than 85% of the effective measured field strength (RMS) specified for the standard radiation pattern, or less than that specified in §73.189(b) for the class of station involved, whichever is the higher value, and that the measured field strength at 1 km in any direction does not exceed the field shown in that direction on the standard radiation pattern for that mode of directional operation:

(i) A tabulation of inverse field strengths in the horizontal plane at 1 km, as determined from field strength measurements taken and analyzed in accordance with §73.186, and a statement of the effective measured field strength (RMS). Measurements shall be made in the following directions:

(A) Those specified in the instrument of authorization.

(B) In major lobes. Generally, one radial is sufficient to establish a major lobe; however, additional radials may be required.

(C) Along additional radials to establish the shape of the pattern. In the case of a relatively simple directional antenna pattern, a total of six radials is sufficient. If two radials would be more than 90 degrees apart, then an additional radial must be specified within that arc. When more complicated patterns are involved, that is, patterns having several or sharp lobes or nulls,

measurements shall be taken along as many as 12 radials to definitely establish the pattern(s). Pattern symmetry may be assumed for complex patterns which might otherwise require measurements on more than 12 radials.

(ii) A tabulation of:

(A) The phase difference of the current in each element with respect to the reference element, and whether the current leads (+) or lags (-) the current in the reference element, as indicated by the station's antenna monitor.

(B) The ratio of the amplitude of the radio frequency current in each element to the current in the reference element, as indicated on the station's antenna monitor.

(iii) A monitoring point shall be established on each radial for which the construction permit specifies a limit. The following information shall be supplied for each monitoring point:

(A) Measured field strength.

(B) An accurate and detailed description of each monitoring point. The description shall include, but shall not be limited to, geographic coordinates determined with a Global Positioning System receiver.

(C) Clear photographs taken with the field strength meter in its measuring position and with the camera so located that its field of view takes in as many pertinent landmarks as possible.

(2) For stations authorized to operate with simple directional antenna systems (e.g., two towers) in the 1605-1705 kHz band, the measurements to support pattern RMS compliance referred to in paragraphs (b)(1)(i)(B) and (b)(1)(i)(C) of this section are not required. In such cases, measured radials are required only in the direction of short-spaced allotments, or in directions specifically identified by the Commission.